SMR-5000

# *Mission Assurance Requirements*

# *for the*

# *Hubble Space Telescope (HST)*
# *HST Robotic Vehicle (HRV)*
# *Robot System (RS)*

## *June 15, 2004*


**Goddard Space Flight Center**
**Greenbelt, Maryland**

This document is a Hubble Space Telescope (HST) controlled document. Changes to this document require prior approval of the HRSDM Project Manager. Proposed changes shall be submitted to the HST Configuration Management Office (CMO), along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

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**HUBBLE SPACE TELESCOPE ROBOTIC SERVICING AND DE-ORBIT MISSION (HRSDM) PROJECT**

**Mission Assurance Requirements**

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**HUBBLE SPACE TELESCOPE ROBOTIC SERVICING AND DE-ORBIT MISSION (HRSDM) PROJECT**

## Mission Assurance Requirements

### DOCUMENT CHANGE RECORD

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# 1.0 OVERALL REQUIREMENTS

This chapter addresses the overall Mission Assurance Requirements (MAR).

## 1.1 DESCRIPTION OF OVERALL REQUIREMENTS

The Contractor is required to plan and implement an organized System Safety and Mission Assurance program that encompasses (1) all flight hardware, either designed/built by the Contractor or furnished by the Goddard Space Flight Center (GSFC), from project initiation through launch and mission operations, (2) ground support equipment (GSE) that interfaces to flight hardware to the extent necessary to assure the integrity and safety of flight items, and (3) all software critical for mission success. This plan shall be documented in a Mission Assurance Plan (MAP) or contractor equivalent, see Section 1.6 and DID 1-1.

## 1.2 USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

Hardware that was designed, fabricated, or flown on a previous project will be considered to have demonstrated compliance with some or all of the requirements of this document such that certain tasks need not be repeated provided that the Contractor can adequately demonstrate how the hardware complies with requirements.

## 1.3 SURVEILLANCE OF THE CONTRACTOR

The work activities, operations, and documentation performed by the Contractor or suppliers are subject to evaluation, review, audit, and inspection by government-designated representatives from GSFC, the Government Inspection Agency (GIA), or an independent assurance contractor (IAC). GSFC will delegate in-plant responsibilities and authority to those agencies via a letter of delegation, or the GSFC contract with the IAC

The contractor and/or suppliers shall grant access for that National Aeronautics and Space Administration (NASA) and/or NASA representatives to conduct an assessment/survey upon notice. Resources shall be provided to assist with the assessment/survey with minimal disturbance to work activities. The contractor, upon request, shall provide government assurance representatives with documents, records, and equipment required to perform their assurance and safety activities. The contractor shall also provide the government assurance representative(s) with an acceptable work area within contractor facilities.

## 1.4 END ITEM DATA PACKAGE

Hardware that is fabricated, assembled, and/or tested shall have a data package that contains pedigree documentation sufficient to validate the hardware as space-flight qualified (see DID 1-2).

## 1.5 APPLICABLE DOCUMENTS

To the extent referenced herein, the documents listed in Chapter 16 form a part of this document.

## 1.6 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

Chapter 17 defines acronyms and abbreviations and Chapter 18 defines the terms as applied in this document.

## 1.7 PROPOSED ALTERNATIVES

The overall intent of this document is to ensure that system safety is properly addressed and that developed hardware and systems will successfully meet NASA and HRSDM requirements. It is recognized, however, that alternative approaches, to those presented here, may accomplish these same goals with less paperwork or in a more productive manner. Accordingly, the Contractor is encouraged to propose alternative methods that might be more efficient, but still meet the needs defined by this document.

## 2.0 QUALITY MANAGEMENT SYSTEM

The Contractor shall have a Quality Management System (QMS) that is compliant with the minimum requirements of American National Standards Institute (ANSI)/ISO/American Society for Quality (ASQ) Q9001 or equivalent. The Contractor's Quality Manual shall be provided in accordance with the SOW (refer to DID 2-1). Certificates issued to ANSI/ISO/ASQC Q9001: 1994 will have a maximum validity of 3 years from the publication date of ANSI/ISO/ASQ Q9001: 2000.

### 2.1 SUPPLEMENTAL QUALITY MANAGEMENT SYSTEM REQUIREMENTS

Some assurance related activities are not covered by ISO requirements. These activities are identified in the following sections and should supplement the ANSI/ISO/ASQ 9001 requirements. The Contractor shall provide a Mission Assurance Plan describing how the requirements in this document will be met. (refer to DID 2-2).

### 2.2 CONFIGURATION MANAGEMENT

The Contractor shall document and maintain a configuration management system to properly manage change control and the functional and physical characteristics of configuration items during design, fabrication, assembly, and testing. The Contractor's Configuration Management Plan shall be available for review by GSFC.

#### 2.2.1 Control of Nonconforming Product

The Contractor shall have a closed loop system for identifying and reporting nonconformances, ensuring that positive corrective action is implemented to preclude recurrence and verification of the adequacy of implemented corrective action by audit and test as appropriate. The system shall include a nonconformance review process, which shall consist of a preliminary review and a Material Review Board (MRB). The HRSDM Project shall be provided access to the DM/HRV related nonconforming reports and corrective action information.

#### 2.2.2 Material Review Board (MRB)

At Contractor/supplier facilities, the NASA/Government representatives will participate in MRB activities as deemed appropriate by GSFC.

#### 2.2.3 Reporting of Nonconformances

Reporting of hardware and software nonconformances shall begin with the first power application at the start of end item acceptance testing or the first operation of a

mechanical item; it shall continue through formal Government acceptance of the end item.

### 2.2.4 Control of Monitoring and Measuring Devices

Testing and calibration laboratories shall be compliant with the requirements of ISO 17025, “General Requirements for the Competence of Testing and Calibration Laboratories”.

### 2.2.5 Flow-Down

The Contractor’s QA and safety programs shall ensure proper flow-down and verification of requirements to all suppliers.

# 3.0 SYSTEM SAFETY

This chapter addresses the System Safety Requirements for the HRSDM Project

## 3.1 SYSTEM SAFETY REQUIREMENTS

The Contractor shall implement a system safety program in accordance with NPG 8715.3 “NASA Safety Manual” and the requirements of this Chapter. The program is expected to provide for early identification and control of hazards during design, fabrication, test, transportation, and ground activities. Operations/hardware that do not comply with OSHA/NASA safety requirements may cause operation to be discontinued until approved by the appropriate authority. Personnel safety will take precedence over schedule.

The following are mandatory compliance requirements for hardware and software:

a. EWR 127-1, “Eastern and Western Range Safety Requirements”.
b. KHB 1710.2, “Kennedy Space Center Safety Practices Handbook
c. NPG 8715.3, “NASA Safety Manual”.

Any testing performed at GSFC shall comply with the safety requirements contained in:

a. GMI 1700.2, “Goddard Space Flight Center Health and Safety Program”.
b. GSFC document 540-PG-8715.1.1, “Mechanical Systems Division Safety Manual – Volume I”
c. GSFC document 540-PG-8715.1.2, “Mechanical Systems Division Safety Manual – Volume II”

Satisfactory compliance with the above requirements is required to gain payload access to the launch site and the subsequent launch.

The Contractor shall participate in Project activities associated with compliance to NPD 8710.3, NASA Policy for Limiting Orbital Debris Generation.

## 3.2 SYSTEM SAFETY DELIVERABLES

The safety deliverables described in the following sections serve to demonstrate launch range safety requirements.

### 3.2.1 System Safety Program Plan

The Contractor shall prepare a System Safety Program Plan (SSPP) (see DID 3-1), that describes in detail, tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate and control hazards, or reduce the associated risk to a level acceptable throughout the system life cycle.

### 3.2.2 Safety Analyses

The Contractor shall conduct or assist GSFC with the following safety analyses.

#### 3.2.2.1 Preliminary Hazard Analysis

The contractor shall perform and document a Preliminary Hazard Analysis (PHA) to identify safety critical areas, to provide an initial assessment of hazards, and to identify requisite hazard controls and follow-on actions.

#### 3.2.2.2 Subsystem Hazard Analysis

The Contractor shall perform and document a Subsystem Hazard Analysis (SSHA) to verify subsystem compliance with safety requirements contained in subsystem specifications and other applicable documents; identify previously unidentified hazards associated with the design of subsystems including component failure modes, critical human error inputs, and hazards resulting from functional relationships between components and equipment comprising each subsystem; and recommend actions necessary to eliminate identified hazards or control their associated risk to acceptable levels.

#### 3.2.2.3 System Hazard Analysis

The Contractor shall perform and document a System Hazard Analysis (SHA) to verify system compliance with safety requirements contained in system specifications and other applicable documents; identify previously unidentified hazards associated with the subsystem interfaces and system functional faults; assess the risk associated with the total system design, including software, and specifically of the subsystem interfaces; and recommend actions necessary to eliminate identified hazards and/or control their associated risk to acceptable levels.

#### 3.2.2.4 Operating and Support Hazard Analysis

The Contractor shall perform and document Operating and Support Hazard Analysis (O&SHA) to evaluate activities for hazards or risks introduced into the system by operational and support procedures and to evaluate adequacy of operational and support procedures used to eliminate, control, or abate identified hazards or risks.

#### *3.2.2.5* Software Safety

Hazards caused by software will be identified as a part of the nominal hazard analysis process, and their controls will be verified prior to acceptance.

## 3.3 SAFETY ASSESSMENT REPORT

The Contractor shall perform and document a comprehensive evaluation of the mishap risk of their system. This safety assessment (refer to DID 3-2) shall identify all safety features of the hardware, software, and system design, as well as procedural related hazards present in the system.

## 3.4 MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

The Contractor shall prepare and submit a Missile System Prelaunch Safety Package (MSPSP) (see DID 3-3) in accordance with EWR 127-1; scope shall include hazards associated with the flight system, ground support equipment, and their interfaces that affect personnel, launch vehicle hardware, or the spacecraft. In addition to identifying hazards, the MSPSP shall also establish a “closed loop” process for tracking all hazards to acceptable hazard control closure through the use of a Verification Tracking Log (VTL), (see DID 3-4). A list of all hazardous/toxic materials and associated material safety data sheets shall be prepared and included in the final MSPSP, as well as a detailed description of the hazardous and safety critical operations associated with the payload. The Contractor Project Manager shall demonstrate compliance with these requirements and shall certify to GSFC and the launch range, through this MSPSP, that all safety requirements have been met.

## 3.5 GROUND OPERATIONS PROCEDURES

The Contractor shall submit, in accordance with the contract schedule, all ground operations procedures (see DID 3-5) to be used at GSFC facilities, other integration facilities, or the launch site. All launch site procedures shall comply with the launch site and NASA safety regulations.

## 3.6 SAFETY NONCOMPLIANCE/WAIVER REQUESTS

When a specific safety requirement cannot be met, the Contractor shall submit an associated safety noncompliance/waiver request (see DID 3-6).

## 3.7 SUPPORT FOR SAFETY MEETINGS

The Contractor shall provide technical support to the HRSDM Project for safety working group meetings, Technical Interface Meetings, and technical reviews, when necessary.

## 3.8 ORBITAL DEBRIS ASSESSMENT

The Contractor shall supply an Orbital Debris Assessment, (see DID 3-7) or the information required to produce the assessment consistent with NPD 8710.3, Policy for Limiting Orbital Debris Generation and NSS 1740.14.

## 3.9 SAFETY REQUIREMENTS COMPLIANCE

The Contractor shall demonstrate that the payload is in compliance with all safety requirements (or NCRs/waivers have been submitted and approved by GSFC and the launch site safety representative) and document this in the MSPSP.

## 3.10 LAUNCH SITE SAFETY SUPPORT

The Contractor shall consider manpower requirements necessary for safety support of hazardous operations at the launch site. Range safety is not responsible for project safety support at the launch ranges.

## 3.11 MISHAP REPORTING AND INVESTIGATION

Any mishaps, incidents, and hazards, and close calls will be reported on a NASA Form NF1627 or equivalent form. Mishaps at GSFC facilities shall be reported in accordance with GPG 8621.1, “Reporting of Mishaps, Incidents, Hazards, and Close Calls”. Additional requirements are contained in GPG 8621.2, Processing Mishap, Incident, Hazard, and Close Call Reports.

# 4.0 RELIABILITY REQUIREMENTS

This chapter addresses the Reliability Requirements for the HRSDM Project.

## 4.1 GENERAL REQUIREMENTS

The Contractor shall plan, document and implement a reliability program that interacts effectively with other project disciplines, including systems engineering, hardware design, software reliability, and mission assurance.

## 4.2 PROBABILISTIC RISK ASSESSMENT

A PRA Planning Document shall be prepared that defines the approach to performing a PRA. The PRA itself shall be performed in accordance with the Contractor's Risk Management Plan. Together the PRA and the PRA planning document shall provide a comprehensive, systematic and integrated approach to identifying undesirable events, the scenarios leading to those events beginning with the initiating event or events, the frequency or likelihood of those events and the event consequences. The assessment shall be used to assist in identifying pivotal events that may protect against, aggravate or mitigate the resulting consequences.

The results of the PRA shall be reported at all system level critical reviews and made available for GSFC inspection upon request.

## 4.3 RELIABILITY ANALYSES

Reliability analyses shall be performed concurrently with design so that identified problem areas can be addressed and correction action taken (if required) in a timely manner

### 4.3.1 Failure Modes and Effects Analysis

A Failure Modes and Effects Analysis (FMEA) shall be performed early in the design phase to identify system design problems. As additional design information becomes available the FMEA shall be refined.

Results of the FMEA shall be used to evaluate the design relative to requirements (e.g., no single instrument failure will prevent removal of power from the instrument). Identified discrepancies shall be evaluated by management and design groups for assessment of the need for corrective action. FMEA results shall be presented at PDR and CDR.

### 4.3.2 Fault Tree Analysis

Fault tree analyses (FTA) shall be performed that address both mission failures and degraded modes of operation. Beginning with each undesired state (mission failure or degraded mission), the fault tree will be expanded to include all credible combinations of events/faults and environments that could lead to that undesired state. Component hardware/software failures, external hardware/software failures, and human factors shall be considered in the analysis

The results of the FTA shall be presented at system level reviews and made available electronically to GSFC upon request.

### 4.3.3 Parts Stress Analyses

Each application of electrical, electronic, and electromechanical (EEE) parts, shall be subjected to stress analyses for conformance with the applicable derating guidelines. The analyses with summary sheets and updates shall be maintained at the Contractor's facility for GSFC to review/audit.

### 4.3.4 Worst Case Analyses

Worst Case Analyses shall be performed on circuits where failures would result in questions to the flightworthiness of the design. This analysis (when performed) shall be made available at the Contractor's facility for GSFC review. The results of any analyses shall be presented at all design reviews starting with PDR.

### 4.3.5 Reliability Assessments and Predictions

When necessary or when agreed-upon with GSFC, the Contractor shall perform comparative numerical reliability assessments and/or reliability predictions to:

a. Evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions

b. Identify the elements of the design which are the greatest detractors of system reliability

c. Identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations

d. Assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable

e. Evaluate the impact of proposed engineering change and waiver requests on reliability

## 4.4 RELIABILITY ANALYSIS OF TEST DATA

The Contractor shall fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

### 4.4.1 Trend Analyses

As part of the routine system assessment, the Contractor shall assess all subsystems and components to determine measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. Trend analysis data shall be reviewed with the operational personnel prior to launch.

### 4.4.2 Analysis of Test Results

The Contractor shall analyze test information, trend data, and failure investigations to evaluate reliability implications. Identified problem areas shall be documented and directed to the attention of Contractor management for action. The results of the analyses shall be presented at design reviews.

## 4.5 LIMITED-LIFE ITEMS

Limited-life items shall be identified and managed by means of a Limited-Items list. The Limited-Items list shall be presented at PDR, CDR and the PSR.

Records shall be maintained that allows evaluation of the cumulative stress (time and/or cycles) for limited-life items starting when useful life is initiated and indicating the project activity that will stress the items. The use of an item whose expected life is less than its mission design life must be approved by GSFC by means of a program waiver.

# 5.0 SOFTWARE ASSURANCE REQUIREMENTS

This chapter addresses the Software Assurance Requirements for the HRSDM Project

## 5.1 GENERAL

For the purposes of Section 5, all references to the Contractor shall include the prime software Contractor, as well as any subcontractors and team members tasked in the development process.

## 5.2 SOFTWARE ASSURANCE

The Contractor shall document (DRD SW-01) and implement a Software Assurance program to address software assurance disciplines and functions for all flight and ground system software. The software assurance program shall apply to software and firmware (including PROMs, EEPROMS, and FPGAs) developed or re-used under this contract, including Government off-the-shelf (GOTS) software, modified off-the-shelf (MOTS) software, and commercial off-the-shelf (COTS) software when included in a NASA system.

### 5.2.1 Software Safety

The Contractor shall conduct a Software Safety program that is integrated with the overall software assurance and systems safety program and is compliant with the software safety requirements of NASA-STD-8719.13.

### 5.2.2 Verification and Validation

The Contractor shall implement a Verification and Validation (V&V) program to ensure that software being developed or maintained satisfies functional, performance, and other requirements at each stage of the development process and that each phase of the development process yields the right product. To assist in the verification and validation of software requirements, the Contractor shall develop and maintain under configuration control a Software Requirements Verification Matrix. This matrix shall document the flow-down of each requirement to the test case and test method used to verify compliance and the test results. The matrix shall be made available to NASA upon request.

V&V activities shall be performed during each phase of the development process and shall include the following:

1. Analysis of system and software requirements allocation, verifiability, testability, completeness and consistency (including analysis of test requirements).
2. Interface analysis (requirements and design levels).
3. Design and code analyses.
4. Walkthroughs and/or inspections (i.e., engineering peer reviews).
5. Formal Reviews.

6. Documented test plans and procedures.
7. Test planning, execution, and reporting.

### 5.2.3 Independent Verification and Validation

The Contractor shall provide all information required for the NASA Independent Verification and Validation (IV&V) effort to NASA IV&V Facility personnel. This includes, but is not limited to, access to all software reviews and reports, contractor plans and procedures, software code, software design documentation, and software problem reporting data. Wherever possible, the Contractor shall permit electronic access to the required information or furnish soft copies of requested information to GSFC and to NASA IV&V personnel.

## 5.3 REVIEWS

### 5.3.1 Software Reviews

The Contractor shall conduct the following formal software reviews:

1. Software Requirements Review (SWRR).
2. Software Preliminary Design Review (SWPDR).
3. Software Critical Design Review (SWCDR).
4. Software Test Readiness Review (SWTRR).
5. Software Acceptance Review (SWAR).

If software is addressed as part of the formal system-level reviews (e.g. SRR, PDR, or CDR), the Contractor shall adhere to the review criteria provided by the GSFC Systems Review Office (see Chapter 9).

### 5.3.2 Engineering Peer Reviews

The Contractor shall implement a program of engineering peer reviews (e.g., design walkthroughs or code inspections) throughout the software development lifecycle to identify and resolve concerns prior to formal system/subsystem level reviews. These reviews shall be commensurate with the scope, complexity, and acceptable risk of the software system/product.

Action items or Requests for Action (RFAs) from engineering peer reviews shall be recorded, maintained, and tracked throughout the development lifecycle.

## 5.4 SOFTWARE CONFIGURATION MANAGEMENT

The Contractor shall develop, document (DRD SW-01), and implement a Software Configuration Management (SCM) system that provides baseline management and control of software requirements, design, source code, data, and documentation.

The Contractor shall create and maintain a Software Configuration Control Board (SWCCB) to manage, assess, and control all changes. An HRSDM Project

representative shall co-chair the SWCCB. The SWCCB shall classify each proposed software change as either a Class I or Class II change. Any changes classified as Class I per the definition below shall be forwarded to the HRSDM Project for disposition and approval. Any changes classified as Class II shall be handled by the Contractor and forwarded to the HRSDM Project for review and concurrence.

Class I changes are defined as those which affect System requirements or Software requirements; Software Safety; Cost or Schedule; or External Interfaces.

## 5.5 SOFTWARE PROBLEM REPORTING AND CORRECTIVE ACTION

The Contractor shall implement a process for Software Problem Reporting and Corrective Action that addresses reporting, analyzing and correcting software nonconformances throughout the development lifecycle. The system and database shall be accessible remotely via the web by HRSDM Project representatives.

After development and starting with the first use of a software component with the flight hardware, software nonconformances shall be reported and dispositioned through the Problem/Failure Reporting system used for flight hardware. There shall be a method of linkage, traceability, or cross-referencing of information between the Software Problem Reporting system and the DM/HRV anomaly reporting system.

## 5.6 GFE, EXISTING AND PURCHASED SOFTWARE

For any Government provided software or firmware, the Contractor shall ensure that the software meets the functional, performance and interface requirements placed upon it. The Contractor shall ensure that the software meets applicable standards, including those for design, code and documentation, or shall secure an HRSDM Project waiver to those standards.

## 5.7 SOFTWARE ASSURANCE STATUS REPORTING

Monthly status reports (DRD SW-16) shall be provided to the HRSDM Project.

## 5.8 NASA SURVEILLANCE OF SOFTWARE DEVELOPMENT

The Contractor shall allow NASA representatives and/or their designate/assignee to perform surveillance activities throughout the entire software development lifecycle.

## 6.0 RESERVED

# 7.0 RISK MANAGEMENT REQUIREMENTS

This chapter addresses the Continuous Risk Management (CRM) requirements for the HRSDM Project.

## 7.1 GENERAL REQUIREMENTS

The Contractor shall document and conduct a project-specific CRM process

## 7.2 PROBABILISTIC RISK ASSESSMENT

The implementation of the CRM process shall include the use of tools and methodologies to support the qualitative and quantitative assessment of risk inherent in the system design and associated development and operations activities. Risk assessments are conducted as part of the system design, analysis and trade study activities. The results of these risk assessments shall be used to support project management decisions with respect to safety and mission success, and programmatic commitments.

Comparative numerical reliability assessments and/or reliability predictions, such as Probabilistic Risk Assessment (PRA) should be employed to:

a. Evaluate alternative design concepts, redundancy or cross- and other reliability goals and requirements as applicable strapping approaches, and part substitutions
b. Identify the elements of the design that are the greatest detractors of system reliability
c. Identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations
d. Assist in evaluating the ability of the design to achieve the mission life requirement
e. Evaluate the impact of proposed engineering change and waiver requests on reliability

The Contractor shall perform Failure Mode and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) described in Chapter 4 of this document. The results of FMEA, FTA and any numerical reliability assessments or predictions shall be reported at system-level critical milestone reviews. The presentations shall include descriptions of how the analysis was used to perform design trade-offs and how the results were taken into consideration when making design or risk management decisions.

## 7.3 RISK LIST

The Contractor shall maintain a Risk List throughout the project life cycle, along with programmatic impacts. The list should indicate which risks have the highest probability, which have the highest consequences, and which risks represent the greatest risk to mission success. The list should also identify actions being taken to address each specific risk. The Risk List shall be configuration controlled.

Risk status shall be communicated on a regular basis to the entire project team and customers

# 8.0 TECHNICAL REVIEW REQUIREMENTS

The Contractor shall support a comprehensive set of independent design reviews that are conducted by the GSFC Systems Review Office (SRO). The reviews cover all aspects of flight and ground hardware, software, and operations for which the Contractor has responsibility. In addition, each Contractor shall conduct a program of planned, scheduled and documented component and subsystem reviews of all aspects of his or her area of responsibility.

## 8.1 GENERAL

For each specified system-level review conducted by the GSFC SRO, the Contractor shall:

a. Develop and organize material for oral presentation to the GSFC review team. Copies of the presentation material will be available at each review.

b. Support splinter review meetings resulting from the major review.

c. Produce written responses to recommendations and action items resulting from the review.

d. Summarize, as appropriate, the results of the Contractor reviews at the component and subsystem level.

## 8.2 REVIEWS

The Contractor shall support the following formal GSFC reviews:

a. System Requirements Review (SRR)
b. Preliminary Design Review (PDR)
c. Critical Design Review (CDR
d. Mission Operations Review (MOR)
e. Pre-Environmental Review (PER) or Test Readiness Review (TRR)
f. Flight Operations Review (FOR)
g. Pre-Ship Review (PSR)
h. Launch Readiness Review (LRR)

# 9.0 DESIGN VERIFICATION REQUIREMENTS

This chapter addresses the design verification requirements for the HRSDM Project.

## 9.1 GENERAL

The Contractor shall conduct a verification program to ensure that the flight system meets the specified mission requirements. The program shall consist of functional demonstrations, analytical investigations, physical measurements and tests that simulate all expected environments. The Contractor shall provide adequate verification documentation including a verification plan and matrix, environmental test matrix and verification procedures. The verification documentation shall be available at all reviews.

GEVS-SE, Rev A shall be used as a baseline guide for developing the verification program. The GEVS-SE document is available at: http://arioch.gsfc.nasa.gov/302/gevs-se/toc.htm. Alternative methods are acceptable provided that the net result demonstrates compliance with the intent of the requirements.

## 9.2 DOCUMENTATION REQUIREMENTS

The following documentation shall be developed.

### 9.2.1 System Performance Verification Plan

A System Performance Verification Plan shall be prepared and define the tasks and methods required to determine the ability of the system to meet each project-level performance requirement (structural, thermal, optical, electrical, guidance/control, Radio Frequency (RF)/telemetry, science, mission operational, etc.) and to measure specification compliance. Limitations in the ability to verify any performance requirement shall be addressed, including the addition of supplemental tests and/or analyses that will be performed and a risk assessment of the inability to verify the requirement.

The plan shall address how compliance with each specification requirement will be verified. If verification relies on the results of measurements and/or analyses performed at lower (or other) levels of assembly, this dependence shall be described.

The following documents may be included as part of the System Performance Verification Plan or as separate documents.

### 9.2.2 Environmental Verification Plan

An Environmental Verification Plan shall be prepared to prescribe the tests and analyses that will collectively demonstrate that the hardware and software comply with the environmental verification requirements.

The Environmental Verification Plan shall provide the overall approach to accomplishing the environmental verification program. For each test, it shall include the level of assembly, the configuration of the item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, necessary functional operations, personnel responsibilities and requirement for procedures and reports. It shall also define a rationale for retest determination that does not invalidate previous

verification activities. When appropriate, the interaction of the test and analysis activity shall be described.

Limitations in the environmental verification program that preclude the verification by test of any system requirement shall be documented. Alternative tests and analyses shall be evaluated and implemented as appropriate, and an assessment of project risk shall be included in the System Performance Verification Plan.

### 9.2.3 System Performance Verification Matrix

A System Performance Verification Matrix shall be prepared and maintained, to show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, results, report reference numbers, etc. This matrix shall be included in the system review data packages showing the current verification status as applicable.

### 9.2.4 Environmental Test Matrix

As an adjunct to the system/environmental verification plan, an environmental test matrix (ETM) shall be prepared that summarizes all tests that will be performed on each component, each subsystem or instrument, and the payload.

A complementary matrix shall be kept showing the tests that have been performed on each component, subsystem, instrument or payload (or other applicable level of assembly). This shall include tests performed on prototypes or engineering units used in the qualification program and shall indicate test results (pass/fail or malfunctions). This matrix shall be included in the system review data packages showing the current verification status as applicable.

### 9.2.5 Environmental Verification Specification

An environmental verification specification shall be prepared that defines the specific environmental parameters that each system element is subjected to either by test or analysis in order to demonstrate its ability to meet the mission performance requirements. Such things as payload peculiarities and interaction with the launch vehicle shall be taken into account.

### 9.2.6 Performance Verification Procedures

For each verification test activity conducted at the component, subsystem, and payload levels of assembly, a verification procedure shall be prepared that describes the configuration of the test article, how each test activity contained in the verification plan and specification will be implemented.

Test procedures shall contain details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, pass/fail criteria, quality control checkpoints, data collection, and reporting requirements. The procedures also shall address safety and contamination control provisions.

### 9.2.7 Verification Reports

After each component, subsystem, payload, and verification activity has been completed, a report shall be prepared. For each analysis activity, the report shall describe the degree to which the objectives were accomplished, how well the mathematical model was validated by related test data, and other such significant results. In addition, as-run verification procedures and all test and analysis data shall be retained for review.

### 9.2.8 System Performance Verification Report

At the conclusion of the verification program, a final system Performance Verification Report shall be delivered comparing the hardware/software specifications with the final verified values (whether measured or computed).

## 10.0 WORKMANSHIP STANDARDS

The Contractor shall plan and implement a Workmanship Program to assure that all electronic packaging technologies, processes and workmanship activities selected and applied meet mission objectives for quality and reliability. See Chapter 15 for additional information on electrostatic discharge (ESD) control

### 10.1 APPLICABLE DOCUMENTS

The current status and/or any application notes for these standards can be obtained at Uniform Resource Locator (URL): http://workmanship.nasa.gov/. The most current version of these standards shall be used for new procurements. However, if a specific revision is listed for a referenced standard, it is that revision only that is approved for use unless otherwise approved by project management.

- Conformal Coating and Staking: NASA-STD-8739.1, "Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies".
- Soldering – Flight, Surface Mount Technology: NASA-STD-8739.2, "Surface Mount Technology".
- Soldering – Flight, Manual (hand): NASA-STD-8739.3, "Soldered Electrical Connections".
- Soldering – Ground Systems: Association Connecting Electronics Industries (IPC)/Electronics Industry Alliance (EIA) J-STD-001C, "Requirements for Soldered Electrical and Electronic Assemblies".
- Electronic Assemblies – Ground Systems: IPC-A-610, "Acceptability of Electronic Assemblies".
- Crimping, Wiring, and Harnessing: NASA-STD-8739.4, "Crimping, Interconnecting Cables, Harnesses, and Wiring".
- Fiber Optics: NASA-STD-8739.5, "Fiber Optic Terminations, Cable Assemblies, and Installation".
- ESD Control: ANSI/ESD S20.20, "Protection of Electrical and Electronic Parts, Assemblies and Equipment" (excluding electrically initiated explosive devices).
- Printed Wiring Board (PWB) Design:
  - IPC-2221, "Generic Standard on Printed Board Design".
  - IPC-2222, "Sectional Design Standard for Rigid Organic Printed Boards".
  - IPC-2223, "Sectional Design Standard for Flexible Printed Boards".
  - IPC D-275 "Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies".
- PWB Manufacture:
  - IPC A-600, "Acceptability of Printed Boards".
  - IPC-6011, "Generic Performance Specification for Printed Boards".

- IPC-6012, “Qualification and Performance Specification for Rigid Printed Boards”
  - Flight Applications – Supplemented with: GSFC/S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
- IPC-6013 “Qualification and Performance Specification for Flexible Printed Boards”.
- IPC-6018 “Microwave End Product Board Inspection and Test.”

## 10.2 DESIGN

### 10.2.1 Printed Wiring Boards

The PWB manufacturing and acceptance requirements identified in this chapter are based on using PWBs designed in accordance with the PWB design standards referenced above. Space flight PWB designs shall not include features that prevent the finished boards from complying with the Class 3 requirements of the appropriate manufacturing standard (e.g., specified plating thickness, internal annular ring dimensions, etc.).

### 10.2.2 Assemblies

The design considerations listed in the NASA workmanship and IPC standards listed above should be incorporated to the extent practical.

### 10.2.3 Ground Data Systems that Interface with Space Flight Hardware

GDS assemblies (this includes ground support equipment) that interface directly with space flight hardware shall be designed and fabricated using space flight parts, materials and processes for any portion of the assemblies that mate with the flight hardware; or that will reside with the space flight hardware in environmental chambers or other test facilities that simulate a space flight environment (e.g., connectors, test cables, etc.).

## 10.3 WORKMANSHIP REQUIREMENTS

### 10.3.1 Training and Certification

All personnel working on flight hardware shall be certified as having completed the required training, appropriate to their involvement, as defined in the above standards or, when approved by project management, in the Contractor’s quality manual.

### 10.3.2 Flight and Harsh Environment Ground Systems Workmanship

#### 10.3.2.1 Printed Wiring Boards

PWBs shall be manufactured in accordance with the Class 3 requirements in the above referenced IPC PWB manufacturing standards and GSFC/S312-P-003, “Procurement

Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses". The Contractor shall provide PWB test coupons to the GSFC Materials Engineering Branch (MEB) or a GSFC/MEB approved laboratory for evaluation. Coupon acceptance shall be obtained prior to population of flight PWBs.

#### 10.3.2.2 Assemblies

Assemblies shall be fabricated using the appropriate workmanship standards listed above (i.e., NASA-STD-8739.3 for hand soldering; NASA-STD-8739.4 for crimping/cabling; NASA-STD-8739.5 for fiber optic termination and installation; NASA-STD-8739.2 for Surface Mount Soldering, etc.) and ANSI/ESD S20.20.

## 10.4 NEW OR ADVANCED MATERIALS AND PACKAGING TECHNOLOGIES

New and/or existing advanced materials and packaging technologies (e.g., multi-chip modules (MCMs), stacked memories, chip on board (COB), ball grid array (BGA), etc.) shall be reviewed and approved by the Parts Control Board defined in Section 12.2.

## 10.5 HARDWARE HANDLING

The Contractor shall use proper safety, ESD control and, where appropriate, cleanroom practices when handling flight hardware. The electrostatic charge generation and contamination potential of materials, processes, and equipment (e.g., cleaning equipment, packaging materials, purging, tent enclosures, etc.) shall be addressed.

# 11.0 PARTS REQUIREMENTS

This chapter addresses the Parts Requirements for the HRSDM Project.

## 11.1 GENERAL

The Contractor shall plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability. The program shall be in place in time to effectively support the design and selection processes.

All parts shall be selected, processed and derated in accordance with GSFC EEE-INST-002, “Instructions for EEE Parts Selection, Screening, Qualification and Derating” for part quality level 1. For those parts not readily available as part quality level 1 but are available at part quality level 2, the parts will require appropriate additional testing to bring them into level 1 compliance.

The Contractor shall control the selection, application, evaluation, and acceptance of all parts through a Parts Control Board (PCB), or another documented system of parts control that is approved by the HRSDM project.

## 11.2 PARTS CONTROL BOARD (PCB)

The Contractor shall establish a Parts Control Board (PCB) or a similar documented system to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. The PCB shall be responsible for the review and approval of all EEE parts, for conformance to established criteria (including radiation effects), and for developing and maintaining a Program Approved Parts List (PAPL). The PCB is responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions.

If there are any parts issues that cannot be resolved at the PCB level, the issues shall be referred to the HST SAM and the HRSDM Project Manager for resolution and disposition.

### 11.2.1 PCB Meetings and Notification

PCB meetings shall be convened on a regular basis or as needed. The GSFC HST Project Parts Engineer will participate in all PCB meetings and shall be notified in

advance of all upcoming meetings. The Contractor shall maintain meeting minutes or records to document all decisions made and an electronic copy provided to GSFC within five working days of convening the meeting. GSFC will retain the right to overturn decisions involving nonconformances within five working days after receipt of meeting minutes.

### 11.2.2 PCB Membership

As a minimum, the PCB membership shall consist of the Contractor, Subcontractors, GSFC HST Project Parts Engineer (PPE) and GSFC Spacecraft Radiation Engineer (RE). The Contractor PPE and GSFC HST Project Parts Engineer will participate in all PCB meetings. The HST Systems Assurance Manager (SAM) (or delegate) will attend as necessary. The GSFC HST Project Parts Engineer (PPE) and GSFC Radiation Engineer (RE) will be permanent working and voting members of the PCB. The Contractor, and Subcontractors PPE shall assure that the appropriate individuals with engineering knowledge and skills are represented as necessary at meetings, such as part commodity specialists, Radiation Engineers or the appropriate subsystem design engineer.

## 11.3 PART SELECTION AND PROCESSING

Parts selected from the NASA Parts Selection List (NPSL) for quality level 1 are preferred. All other EEE parts shall be selected, manufactured, processed, screened, and qualified, as a minimum, to the level 1 requirements of GSFC EEE-INST-002.

## 11.4 CUSTOM OR ADVANCED TECHNOLOGY DEVICES.

Devices such as custom hybrid microcircuits, detectors, ASICs, and MCMs shall also be subject to parts control and include a design review appropriate for the individual technology. The design review shall address items such as element analysis and, when necessary. A Customer Source Inspection may be required.

## 11.5 PLASTIC ENCAPSULATED MICROCIRCUITS (PEMS)

The use of Plastic Encapsulated Microcircuits and plastic semi-conductors is discouraged. However, when use is necessary to achieve unique requirements that cannot be found in hermetic high reliability microcircuits, plastic encapsulated parts, must meet the requirements of NASA GSFC Supplement to GFSC EEE-INST-002, INSTRUCTIONS FOR PLASTIC ENCAPSULATED MICROCIRCUITS (PEMs) SELECTION, SCREENING AND QUALIFICATION. The PCB shall review the procurement specification for appropriate testing, and also review application, procurement and storage processes for the plastic encapsulated part(s) to assure that

all aspects of the GSFC policy have been met. The PCB may grant Preliminary Approval when the GSFC requirements have been met. Final approval for the use of the PEM(s) shall be obtained from the HRSDM Program Office.

## 11.6 DERATING

All EEE parts shall be used in accordance with the derating guidelines of GSFC EEE-INST-002. The Contractor's derating policy may be used in place of the guidelines and shall be submitted with the Contractors PCP. The Contractor shall maintain documentation on parts derating analysis and make it available for GSFC review. Compliance with parts derating shall be demonstrated at spacecraft qualification temperatures.

## 11.7 RADIATION REQUIREMENTS FOR PART SELECTION

All parts shall be selected to perform their function in their intended application for a 2X mission radiation dose based on The Radiation Environment for the HRSDM Project, and any associated analyses. The radiation environment poses three main risks to active parts that must be considered during part selection as identified below.

### 11.7.1 Total Ionizing Dose (TID)

TID including Enhanced Low Dose Rate (ELDR) effects. Parts shall be selected to ensure their adequate performance in the application up to a dose of 2x the expected mission dose. Linear bipolar parts shall be assumed to be ELDR susceptible unless the parts have been successfully tested and shown to be in sensitive.

### 11.7.2 Displacement Damage

Parts shall be selected to ensure their adequate performance in the application up to a dose of 2x the expected mission displacement damage dose. As an example, for silicon devices, and assuming shielding equivalent to 100 mils aluminum, parts must be able to withstand a minimum fluence equivalent to $2.68 \times 10^{12}$ Protons/cm$^2$ (Si) at an equivalent energy level of 50 MeV without system-level degradation. Again, because of the dominance of electrons in geostationary orbit, displacement damage decreases rapidly with added shielding up to at least the first 300 mils Al equivalent.

### 11.7.3 Single Event Effects (SEE)

The contractor shall carry out an analysis documenting the consequences of single-event induced error modes to the part, circuit, subsystem, system and spacecraft. In particular, the analysis shall consider the consequences of Single Event Upset (SEU) or Single Event Transient (SET) in each application of the part. Parts susceptible to Single Event Latch up (SEL) should be avoided.

## 11.8 PART ANALYSIS

### 11.8.1 Destructive Physical Analysis

A sample of each lot date code of microcircuits, hybrid microcircuits, EMI filters, relays, capacitors, oscillators, and semiconductor devices shall be subjected to a Destructive Physical Analysis (DPA) as determined by the PCB.

### 11.8.2 Failure Analysis

The Contractor shall perform part Failure Analysis essential to achieve a timely resolution and closeout of each failure incident. The Contractor PPE shall submit the completed EEE part failure report with all supporting data, analyses, and photographs to the PCB for review and approval.

## 11.9 Parts Age and Storage Control

All parts procured with date codes indicating that more than five (5) years have elapsed from the date of manufacture to date of procurement shall be subjected to a re-screen and sample DPA per PCB recommendation. Alternate test plans may be used as approved by the PCB on a case-by case basis. Parts taken from user inventory older than 5 years do not require re screen, provided they have been properly stored. Parts over 10 years from the date of manufacture to date of procurement or stored in other than controlled conditions where they are exposed to the elements or sources of contamination shall not be used.

## 11.10 Parts Used in Off-the-Shelf Assemblies

Units or assemblies that are purchased as “off-the-shelf” hardware items shall be subjected to an evaluation of the parts used within them. The parts shall be evaluated

for screening compliance to GSFC EEE-INST-002, established reliability level, and include a radiation analysis. Units may be required to undergo modification for use of higher reliability parts or Radiation hardened parts. All parts shall be subject to PCB approval.

Modifications such as additional shielding for radiation effectiveness or replacing radiation soft parts for radiation hardened parts may be required and shall be subject to RE approval.

## 11.11 VALUE ADDED TESTING

The following value added tests provide for enhanced reliability of parts and all additional testing shall be noted in the PAPL. Unless otherwise specified, testing shall be in accordance with the test methods referenced in GSFC EEE-INST-002.

### 11.11.1 Particle Impact Noise Detection (PIND)

All EEE devices with internal cavities (transistors, microcircuits, hybrids, relays and switches) shall be subjected to Particle Impact Noise Detection (PIND) screening, in accordance with the applicable specification. Any device failing this screen shall not be used in any flight application.

### 11.11.2 Capacitors

#### 11.11.2.1 Surge Current Screening for Tantalum Capacitors

All solid tantalum capacitors used in filtering applications shall be subjected to surge current screening. Chip devices (CWR06 for example) shall receive testing in accordance with MIL-PRF-55365 (+25°C only). This testing can be performed at the manufacturer's facilities by adding an "A" suffix to the standard military part number. Leaded devices (M39003/01 for example) shall receive testing in accordance with MIL-PRF-39003/10.

#### 11.11.2.2 Dielectric Screening for Ceramic Capacitors

Ceramic capacitors used in circuits at or below 10V shall be rated at 100V or greater except as follows. Each lot of capacitors rated below 100V, shall have samples subjected to Humidity Steady State Low Voltage testing (85°C and 85% relative humidity) in accordance with MIL-PRF-123 (12 piece sample for each lot/date code).

Following humidity exposure, a Destructive Physical Analysis (DPA) shall be performed in accordance with MIL-PRF-123 (sample size per GSFC S-311-M-70, for each lot/date code) prior to acceptance.

### 11.11.3 Screening for Magnetic Components

Magnetic devices (transformers and inductors) shall be assembled and screened to the requirements of MIL-STD-981 (Design, Manufacturing and Quality Standards for Custom Electromagnetic Devices for Space Applications) for class S devices. Burn-in screening shall be considered based on vendor history, performance stability requirements, device complexity, and application criticality.

Simple toroidal coils with one layer of windings may be exempted from burn in unless required by the core manufacturer to stabilize its properties, and such decisions require PCB documentation and approval.

## 11.12 PARTS LIST

The Contractor shall create and maintain a Program Approved Parts List (PAPL) and Parts Identification List_(PIL) for the duration of the program. Clear distinctions shall be made as to parts approval status and whether parts are planned for use in flight hardware. Parts must be approved for listing on the PAPL and PIL before initiation of procurement activity.

### 11.12.1 Program Approved Parts List (PAPL)

The PAPL shall be the only listing of approved parts for flight hardware, and as such may contain parts not actually in flight design. Only parts that have been evaluated and approved by the PCB shall be listed in the PAPL. The PCB shall assure standardization and the maximum use of parts listed in the PAPL. (See Table 12-1)

### 11.12.2 Parts Identification List (PIL)

The PIL shall list all parts proposed for use in flight hardware. The PIL is prepared from design team inputs or subcontractor inputs, to be used for presenting candidate parts to the PCB. The PIL shall include as a minimum the following information: part number, part name or description, manufacturer, manufacturer's generic part number, drawing number, specifications, comments as necessary to indicate problems, long lead times, additional testing imposed, application unique notes, etc.

### 11.12.3 As-Designed Parts List (ADPL)

The Contractor PPE shall establish an As-Designed Parts List (ADPL) as soon as practical after the preliminary release of designs for CDR. The GSFC PPE will maintain a copy in the NASA Electronics Parts database, and will work with the design teams to keep the list(s) current. (See Table 11-1) The Contractor shall submit the final version of the ADPL in accordance contract requirements.

### 11.12.4 As-Built Parts List (ABPL)

An As-Built Parts List (ABPL) shall also be prepared and submitted with the hardware. The ABPL is generally a final compilation of all parts as installed in flight equipment, with additional "as-installed" part information such as manufacturer name, CAGE code, Lot-Date Code, part serial number (if applicable), quantity used and box or board location. The manufacturer's plant specific CAGE code is preferred, but if unknown, the supplier's general cage code is sufficient (See Table 11-1)

## 11.13 Alerts

The Contractor and sub-contractors shall be responsible for the review and disposition of all GIDEP Alerts for impact on parts proposed for flight use. In addition, any NASA Alerts and Advisories provided to the Contractor by GSFC shall be reviewed and dispositioned. Alert applicability, impact, and corrective actions shall be documented and delivered in accordance with the HRSDM Program requirements (see Chapter 15).

## 11.14 ADDITIONAL REQUIREMENTS

### 11.14.1 Traceability

The Contractor shall utilize traceability database(s) that provide the capability to retrieve historical records of EEE parts from initial procurement and receipt through, storage, kiting, assembly, test, and final acceptance of the deliverable product. Also, the database shall permit the traceability to the procurement document and provide for:

1. Cross-referencing and traceability of part manufacturer and date code to the assembly traveler or production plan.
2. The storage of the accumulated data records.

All flight EEE parts shall be traceable to the date code or manufacturer's inspection lot, wafer lot (where applicable). Traceability shall be maintained throughout manufacturing for each deliverable item.

### 11.14.2 Prohibited Metals

Pure tin plating shall not be used in the construction and surface finish of EEE parts proposed for space hardware. Only alloys containing less than 97% tin are acceptable.

The use of cadmium or zinc is prohibited in the construction and surface finish of space hardware. All cadmium alloys or zinc alloys (e.g. brass) shall be completely over plated with an approved metal.

### 11.14.3 PCB Supplier and Manufacturer Surveillance (Monitoring)

The PCB shall establish a policy and procedures for the periodic surveillance and auditing of suppliers, vendors, laboratories and manufacturers to ensure compliance to procurement, quality, reliability and survivability requirements. Contractor's surveillance of laboratories, suppliers, vendors, and manufacturers that have been approved as a part of Qualified Parts List (QPL) or Qualified Manufacturer's List (QML) program for products listed in the space quality baseline is not required. When surveillance/audit data is available from other sources (e.g. other contractor programs, other contractor sub-contractors, independent audits reports, etc.) the contractor may utilize the results of the data contingent on the review and approval by the PCB. Acceptability of the data shall be based on technical considerations, as well as timeliness and confidence in the source of the data.

### 11.14.4 Reuse of Parts and Materials

Parts and materials which have been installed in an assembly, and are then removed from the assembly for any reason, shall not be used again in any item of flight or spare hardware without prior approval of the PCB based on the submission of evidence that this practice does not degrade the system performance.

## 11.15 DATA REQUIREMENTS

General

Attributes (parametric test) summary data shall be available to GSFC for all testing performed. Variable data (read and record) shall be recorded for initial, interim and final electrical test points. Test data shall be available to GSFC.

For those parts potentially susceptible to radiation effects in the HRV environment, a summary radiation report that identifies parameter degradation behavior shall be provided to the PCB. Variable data acquired during radiation testing shall be available to GSFC.

### 11.15.1 Retention of Data and Test Samples.

All builders of flight hardware shall have a method in place for retention of data generated for parts tested and used in flight hardware. The data shall be kept on file in order to facilitate future risk assessment and technical evaluation, as needed. In addition, the prime contractor and subcontractors shall retain all part functional failures, all destructive and non-flight non-destructive test samples, which could be used for future validation of parts for performance under certain conditions not previously accounted for. PIND test failures may be submitted for DPA, radiation testing or used in engineering models. Parts and data shall be retained for the useful life of the spacecraft, unless otherwise permitted by the PCB.

All historical quality records and those data required to support these records shall be retained for until end of contract completion.

### 11.15.2 End Item Acceptance Package

The Contractor PPE and each Subcontractor PPE shall establish and maintain a EEE parts data package for each unit level assembly produced under the contract. The data package shall identify and include all applicable lower level part and subassembly data and provide test data to support assembly performance. Each package shall contain, as a minimum:

1. Manufacturing/inspection history; “As- designed’’ to ‘’As- Built” parts list configuration comparison.
2. EEE part nonconformance documentation, including part failure reports, and waiver/deviation reports
3. Photographs, refer to section 12.18.3.
4. Dispositions for installed parts impacted by GIDEP alerts / NASA Problem Advisories, or purges; and, other data relevant to acceptance of the hardware.
5. All historical quality records and those data required to support these records shall be retained for a period of 20 years, or end of contract completion.

### 11.15.3 Photographic Requirements

The Contractor shall provide a digital photographic record of each electronic PWB and subassembly. The photograph shall be of sufficient resolution to clearly show component placement, part marking, or details that are covered or obscured at subsequent levels of assembly and/or any other operation that renders subsequent inspection impractical. Photographs shall also be provided of the end item clearly showing all critical details.

Each photograph shall be identified with a label containing the following information: assembly number, serial number, description (e.g. name of the assembly), date of photo, and the supplier's company name. The subject shall appropriately fill the digital frame to allow for effective magnification. The image shall be of sufficient resolution to permit identification of components and verification of wire routings. The resolution shall also permit further enlargement of the image if required for analysis.

Photographic images shall be a minimum 6.0 Mega pixel digital image file. A complete set of photographs shall be included in each end item data package.

**Table 11-1 Required Fields**

| Field | Required Field for Parts List Type | | |
|---|---|---|---|
| | ADPL | PAPL | ABPL |
| Item Number | X | X | X |
| Spacecraft Name | X | X | X |
| Instrument Name | X | X | X |
| Generic Part Number | X | X | X |
| Procurement Part Number | X | X | X |
| Flight Part Number | | X | X |
| Description | X | X | X |
| Package: Case Style and Number of Pins | X | X | X |
| Lot Date Code | | | X |
| Manufacturer | X | X | X |
| Cage Code | X | X | X |

| | | | |
|---|---|---|---|
| Distributor | X | | |
| Additional Testing Required | X | X | |
| Quantity needed | X | | X |
| Quantity Procured | X | | |
| Radiation Hardness Evaluation: TID, Krads | X | X | X |
| Radiation Hardness Evaluation: SEL, MeV | X | X | X |
| Radiation Hardness Evaluation: SEU, MeV | X | X | X |
| Radiation Hardness Evaluation: Displacement Damage | X | X | X |
| Radiation Data Source: TID | X | | |
| Radiation Data Source: SEE | X | | |
| Notes | X | | |
| | | | |
| PMCB Comments | X | X | |
| Approval Date | X | X | X |
| Box Identification | X | X | X |
| Part Location (Circuit Identifier) | | | X |

# 12.0 MATERIALS SELECTION

This chapter addresses the Materials, Processes, and Lubrication Requirements for the HRSDM Project.

## 12.1 GENERAL REQUIREMENTS

The Contractor shall implement a comprehensive Materials, Processes and Lubrication plan In order to anticipate and minimize materials problems during space hardware development and operation. When selecting materials and lubricants, the Contractor shall consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxic offgassing, flammability and fracture toughness, as well as the properties required by each material usage or application.

The HST Materials Assurance Engineer (MAE) must concur with all materials, lubricants and material processes used for the spaceflight hardware.

## 12.2 COMPLIANT MATERIALS

The Contractor shall use compliant materials in the fabrication hardware to the extent practicable. In order to be compliant, a material must be used in a conventional application and meet the applicable selection criteria identified below. A compliant material does not require an MUA.

1. Hazardous materials requirements, including flammability, toxicity and compatibility as specified in EWR 127-1 Range Safety Requirements2.
2. Vacuum Outgassing requirements as defined in paragraph 12.2.4.
3. Stress corrosion cracking requirements as defined in Marshall Space Flight Center MSFC-STD-3029.

### 12.2.1 Non-compliant Materials

A material that does not meet the above requirements, or meets the requirements, but is used in an unconventional application, will be considered to be a non-compliant material. The proposed use of a non-compliant material requires that a MUA be submitted to the HST MAE for approval.

### 12.2.2 Polymeric Materials

The Contractor shall prepare and submit a polymeric materials and composites usage list. The list shall be submitted to the HST MAE, in electronic format, for review and approval (see DID 12-1).

### 12.2.3 Flammability and Toxic Offgassing

Material flammability and toxic offgassing shall be determined in accordance with the test methods described in NASA-STD-6001. Payload materials shall meet the requirements of EWR 127-1 Range Safety Requirements.

### 12.2.4 Vacuum Outgassing

Material vacuum outgassing shall be determined in accordance with American Society for Testing of Materials (ASTM) E-595. In general only materials that have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10% will be approved for use in a vacuum environment.

### 12.2.5 Shelf-Life-Controlled Materials

Polymeric materials that have a limited shelf-life shall be controlled by a process that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf-life, and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints shall be included. The use of materials whose date code has expired requires that the Contractor demonstrate, by means of appropriate tests, that the properties of the materials have not been compromised for their intended use. Such materials shall be approved by the HST MAE. When a limited-life piece part is installed in a subassembly, its usage shall be approved by the HST Materials Assurance Engineer.

### 12.2.6 Inorganic Materials

The Contractor shall prepare and document an inorganic materials usage list or the Contractor's equivalent. The list shall be submitted, in electronic form, to the HST Materials Assurance Engineer for review and approval (see DID 12-2). In addition, the Contractor may be requested to submit supporting applications data. The criteria specified in MSFC-STD-3029 shall be used to determine that metallic materials meet the stress corrosion cracking criteria. An MUA shall be submitted for each material usage that does not comply with the MSFC-STD-3029 requirements. Additionally, for the HST Materials Assurance Engineer to approve usage of individual materials, a stress corrosion evaluation form or an equivalent Contractor form or any/all of the information contained in the stress corrosion evaluation form may be required from the Contractor.

The use of tin, zinc, and cadmium platings in any flight application requires an MUA prior to use of that material.

### 12.2.7 Fasteners

As part of the parts and materials list approval process, the HST Materials Assurance Engineer will approve all flight fasteners. Towards this end, the Contractor shall provide all information needed by the HST Materials Assurance Engineer to ensure its ability to concur with the flightworthiness of flight fasteners. The Contractor shall comply with the procurement documentation and test requirements for flight hardware and critical

ground support equipment fasteners contained in 541-PG-8072.1.2, GSFC Fastener Integrity Requirements.

### 12.2.8 Lubrication

The Contractor shall prepare and document a lubrication usage list or the Contractor's equivalent. The list shall be submitted to the HST Materials Assurance Engineer for review and approval. The Contractor may be requested to submit supporting applications data.

### 12.2.9 Process Selection

The Contractor shall prepare and document a material process utilization list. The list shall be submitted to the HST MAE for review and approval. A copy of any process shall be submitted for review upon request.

### 12.2.10 Procurement Requirements

#### 12.2.10.1 Purchased Raw Materials

Raw Materials purchased by the Contractor shall be accompanied by the results of nondestructive, chemical, and physical tests, or a Certificate of Compliance. This information need only be provided to GSFC when there is a direct question concerning the material's flightworthiness.

#### 12.2.10.2 Raw Materials used in Purchased Products

The Contractor shall require that their suppliers meet the requirements of this Chapter and provide, upon request, the results of acceptance tests and analyses performed on raw materials.

# 13.0 CONTAMINATION CONTROL REQUIREMENTS

This chapter addresses the Contamination Control Requirements for the HRSDM Project

## 13.1 General

The Contractor shall document and implement a contamination control program appropriate for the hardware. The program shall establish the specific cleanliness requirements and delineate the approaches to be followed.

## 13.2 CONTAMINATION CONTROL VERIFICATION PROCESS

The Contractor shall develop a contamination control verification process. The verification process shall be performed in order

a. Determination of contamination sensitivity;
b. Determination of a contamination allowance;
c. Determination of a contamination budget;
d. Development and implementation of a contamination control plan.

## 13.3 CONTAMINATION CONTROL PLAN (CCP)

The Contractor shall document the procedures that will be followed to control contamination. The CCP shall be provided to GSFC for review and approval.

## 13.4 MATERIAL OUTGASSING

In accordance with ASTM E595, NASA RP 1124 may be used as a guide. Individual material outgassing data shall be established based on each component's operating conditions. Established material outgassing data shall be verified and shall be reviewed by GSFC.

## 13.5 THERMAL VACUUM BAKEOUT

The Contractor shall perform thermal vacuum bakeouts of all hardware. The parameters of such bakeouts (e.g., temperature, duration, outgassing requirements, and pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance.

## 13.6 HARDWARE HANDLING

The Contractor shall practice cleanroom standards in handling hardware. The contamination potential of material and equipment used in cleaning, handling,

packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging shall be described in detail for each subsystem or component at each phase of assembly, integration, test, and launch.

## 14.0 ELECTROSTATIC DISCHARGE CONTROL

The Contractor shall document and implement an ESD Control Program in accordance with ANSI/ESD S20.20 to assure that all manufacturing, inspection, testing, and other processes will not compromise mission objectives for quality and reliability due to ESD events.

## 15.0 GIDEP ALERTS AND PROBLEM ADVISORIES

The Contractor shall participate in the GIDEP in accordance with the requirements of the GIDEP SO300- BT-PRO-010 and SO300-BU-GYD-010, available from the GIDEP Operations Center, Post Office (PO) Box 8000, Corona, California 92878-8000.

The Contractor shall review all GIDEP ALERTS, GIDEP SAFE-ALERTS, GIDEP Problem Advisories, GIDEP Agency Action Notices, NASA Advisories and any informally documented component issues presented by Code 303, to determine if they affect the Contractor products produced for NASA. For GIDEP ALERTS, GIDEP SAFE-ALERTS, GIDEP Problem Advisories, GIDEP Agency Action Notices and NASA Advisories that are determined to affect the program, the Contractor shall take action to eliminate or mitigate any negative effect to an acceptable level. The Contractor shall generate the appropriate failure experience data report(s) (GIDEP ALERT, GIDEP SAFE-ALERT, GIDEP Problem Advisory) on a monthly basis, in accordance with the requirements of GIDEP SO300-BT-PRO-010 and SO300-BU-GYD-010 whenever failed or nonconforming items, available to other buyers, are discovered during the course of the contract.

## 16.0 APPLICABLE DOCUMENTS LIST

| DOCUMENT | DOCUMENT TITLE |
|---|---|
| ANSI/ASQC Q9000-3 | Quality Management and Quality Assurance Standards – Part 3: Guidelines for the Application of ISO 9001 to the Development, Supply and Maintenance of Software |
| ANSI/ISO/ASQ Q9001:2000 | American National Standard Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation and Servicing |
| ANSI/ESD S20.20 | ESD Association Standard for the Development of an Electrostatic Discharge Control Program for protection of electrical and electronic parts, assemblies, and equipment (excluding electrically initiated explosive devices). |
| ANSI/IPC-A-600 | Acceptability of Printed Boards. |
| ASTM E-595 | Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment |
| EWR 127-1 | Eastern and Western Range Safety Requirements |
| FAR | Federal Acquisition Regulations |
| GEVS-SE | General Environmental Verification Specification for STS and ELV Payloads, Subsystems and Components. |
| GMI 1700.2 | Goddard Space Flight Center Health and Safety Program |

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| GPG 8621.2 | Processing Mishap, Incident, Hazard, and Close Call Reports |
| GPG 8621.3 | Mishap, Incident, Hazard, and Close Call Investigation |
| GPG 8700.4 | Technical Review Program |
| GPG 8700.6 | Engineering Peer Reviews |
| GSFC S-312-P003 | Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses |
| GSFC EEE-INST-002 | Instructions for EEE Parts Selection, Screening, and Qualification and Derating |
| IEEE STD 610.12 | IEEE Standard Glossary for Software Engineering Terminology |
| IEEE STD 730 | IEEE Standard for Software Quality Assurance Plans |
| IEEE STD 982.2 | IEEE Guide for the Use of IEEE Standard Dictionary of Measures to Produce Reliable Software |
| IPC A-600 | Acceptability of Printed Boards |
| IPC-A-610 | Acceptability of Electronic Assemblies |
| IPC D-275 | Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies |

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| IPC/EIA J-STD-001 | Requirements for Soldered Electrical and Electronic Assemblies |
| IPC-2221 | Generic Standard on Printed Board Design |
| IPC-2222 | Sectional Design Standard for Rigid Organic Printed Boards |
| IPC-2223 | Sectional Design Standard for Flexible Printed Boards |
| IPC-6011 | Generic Performance Specifications for Printed Boards |
| IPC-6012 | Qualification and Performance Specification for Rigid Printed Boards |
| IPC-6013 | Qualification and Performance Specification for Flexible Printed Boards |
| IPC-6018 | Microwave End Product Board Inspection and Test |
| ISO 17025 | General Requirements for the Competence of Testing and Calibration Laboratories |
| JSC 26943 | Guidelines for the Preparation of Payload Flight Safety Data Packages and Hazard Reports |
| KHB 1710.2 | Kennedy Space Center Safety Practices Handbook |
| MIL-HDBK-217 | Reliability Prediction of Electronic Equipment |

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|---|---|
| MIL-HDBK-470 | Designing and Developing Maintainable Products and Systems |
| MIL-HDBK-472 | Maintainability Prediction |
| MIL-STD-461 | Electromagnetic Emission and Susceptibility Requirement for Control of Electromagnetic Interference |
| MIL-STD-756 | Reliability Modeling and Prediction |
| MIL-STD-1629 | Procedures for Performing a Failure Mode Effects and Criticality Analysis |
| MSFC CR 5320.9 | Payload and Experiment Failure Mode Effects Analysis and Critical Items List Ground Rules |
| MSFC-HDBK-527 | Material Selection List for Space Hardware Systems |
| MSFC-SPEC-522 | Design Criteria for Controlling Stress Corrosion Cracking |
| NASA RP-1124 | Outgassing Data for Selecting Spacecraft Materials |
| NASA RP-1161 | Evaluation of Multi-layer Printed Wiring Boards by Metallographic Techniques |
| NHB 8060.1 | Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion |
| NPD 8700.1 | NASA Policy for Safety & Mission Success |

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| NPD 8710.3 | NASA Policy for Limiting Orbital Debris Generation |
| NPG 7120.5 | NASA Program and Project Management Processes and Requirements |
| NPG 8000.4 | Risk Management Procedures and Guidelines |
| NPG 8715.3 | NASA Safety Manual |
| NASA-STD-2100-91 | Software Documentation Standard |
| NASA-STD-2201-93 | Software Assurance Standard |
| NASA-STD-2202-93 | Software Formal Inspections Standard |
| NASA-STD-6001 | Flammability, Odor, Off-gassing and Compatibility Requirements & Test Procedures for Materials in Environments that Support Combustion |
| NASA-STD 8719.13 | NASA Software Safety Standard |
| NASA-STD 8719.14 | Guidelines and Assessment Procedures for Limiting Orbital Debris |
| NASA-STD-8739.1 | Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies |
| NASA-STD-8739.2 | Workmanship Standard for Surface Mount Technology |

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| NASA-STD-8739.3 | Workmanship Standard for Soldered Electrical Connections |
| NASA-STD-8739.4 | Workmanship Standard for Crimping, Interconnecting Cables, Harnesses and Wiring |
| NASA-STD-8739.5 | Workmanship Standard for Fiber Optic Terminations, Cable Assemblies and Installation |
| NSS 1740.13 | NASA Software Safety Standard |
| NSS 1740.14 | Guidelines and Assessment Procedures for Limiting Orbital Debris |
| NSTS 14046 | Payload Verification |
| NSTS 22648 | Flammability Configuration Analysis for Spacecraft Applications |
| NSTS/ISS 13830 | Payload Safety Review and Data Submittal Requirements |
| NSTS/ISS 18798 | Interpretations of NSTS/ISS Payload Safety Requirements |
| S-302-89-01 | Procedures for Performing a Failure Mode and Effects Analysis |
| S-311-M-70 | Specification for Destructive Physical Analysis |
| SAE AS9100 | Aerospace Standard, Quality Systems Model for Quality Assurance, Design, Development, Production, Installation and Servicing |

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| SAE JA1002 | Software Reliability Program Standard |
| 540-PG-8715.1.1 | Mechanical Systems Division Safety Manual – Volume I |
| 540-PG-8715.1.2 | Mechanical Systems Division Safety Manual – Volume II |
| 541-PG-8072.1.2 | GSFC Fastener Integrity Requirements |
| 5405-048-98 | Mechanical Systems Center Safety Manual |

# 17.0 ACRONYMS AND ABBREVIATIONS

| Acronym/ Abbreviation | Definition |
|---|---|
| ABPL | As-Built Parts List |
| ADPL | As-Designed Parts List |
| ANSI | American National Standards Institute |
| AR | Acceptance Review |
| ASQC | American Society for Quality Control |
| ASIC | Application Specific Integrated Circuits |
| ASTM | American society for Testing of Materials |
| BGA | Ball Grid Array |
| BOL | Beginning of Life |
| CCP | Contamination Control Plan |
| CDR | Critical Design Review |
| CDRL | Contract Delivery Requirements List |
| COB | Chip on Board |
| COTS | Commercial off-the shelf |
| CPT | Comprehensive Performance Test |
| CVCM | Collected Volatile Condensable Mass |
| DID | Data Item Description |
| DM | De-orbit Module |
| DoD | Department of Defense |
| DPA | Destructive Physical Analysis |
| DRD | Data Requirements Description |
| DRP | Design Review Program |
| DRT | Design Review Team |
| EEE | Electrical, Electronic, and Electromechanical |
| EEPROMS | Electrically Erasable PROMS |
| ELDR | Enhanced Low Dose Rate |
| ELV | Expendable Launch Vehicle |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| EOL | End of Life |
| ESD | Electrostatic Discharge |

| Acronym/ Abbreviation | Definition |
|---|---|
| ETM | Environmental Test Matrix |
| EWR | Eastern and Western Range |
| FMEA | Failure Modes and Effects Analysis |
| FOR | Flight Operations Review |
| FPGA | Field Programmable Gate Array |
| FTA | Fault Tree Analysis |
| GDS | Ground Data Systems |
| GEVS | General Environmental Verification Specification |
| GEVS-SE | General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components |
| GFE | Government-Furnished Equipment |
| GIA | Government Inspection Agency |
| GIDEP | Government Industry Data Exchange Program |
| GMI | Goddard Management Instruction |
| GOTS | Government off-the-shelf |
| GSE | Ground Support Equipment |
| GSFC | Goddard Space Flight Center |
| HRSDM | Hubble Space Telescope Robotic Servicing and De-orbit Mission |
| HRV | Hubble Robotic Vehicle |
| IAC | Independent Assurance Contractor |
| ICD | Interface Control Document |
| IV&V | Independent Verification and Validation |
| JSC | Johnson Space Center |
| KHB | Kennedy Handbook |
| LPT | Limited Performance Test |
| LRR | Launch Readiness Review |
| MAE | Materials Assurance Engineer |
| MAG | Mission Assurance Guidelines |
| MAP | Mission Assurance Plan |
| MAR | Mission Assurance Requirements |
| MEB | Materials Engineering Branch |
| MCM | Multi-Chip Module |
| MO&DSD | Mission Operations and Data Systems Directorate |
| MOR | Mission Operations Review |
| MOTS | Modified off-the-shelf |

| Acronym/ Abbreviation | Definition |
|---|---|
| MRB | Material Review Board |
| MSFC | Marshall Space Flight Center |
| MSPSP | Missile System Pre-launch Safety Package |
| MSR | Management Status Report |
| MUA | Materials Usage Agreement |
| NAS | NASA Assurance Standard |
| NASA | National Aeronautics and Space Administration |
| NCR | Non Conformance Report |
| NF | NASA Form |
| NHB | NASA Handbook |
| NPD | NASA Policy Directive |
| NPG | NASA Procedures and Guidelines |
| NPSL | NASA Parts Selection List |
| NSS | NASA Safety Standard |
| NSTS | National Space Transportation System |
| OSHA | Occupational Safety and Health Administration |
| OSSMA | Office of Systems Safety and Mission Assurance |
| PAPL | Project Approved Parts List |
| PCB | Parts Control Board |
| PCP | Parts Control Plan |
| PEM | Plastic Encapsulated Microcircuits |
| PDR | Preliminary Design Review |
| PER | Pre-Environmental Review |
| PFR | Problem/Failure Report |
| PHA | Preliminary Hazard Analysis |
| PI | Principal Investigator |
| PIL | Parts Identification List |
| PIND | Particle Impact Noise Detection |
| POCC | Payload Operations Control Center |
| PPE | Project Parts Engineer |
| PPL | Preferred Parts List |
| PRA | Probabilistic Risk Assessment |
| PROMS | Programmable Read Only Memories |
| PSR | Pre-Shipment Review |
| PWB | Printed Wiring Board |

| Acronym/ Abbreviation | Definition |
|---|---|
| QML | Quality Manufacturer's List |
| QMS | Quality Management System |
| QPL | Quality Parts List |
| RFP | Request for Proposal |
| RE | Radiation Engineer |
| RF | Radio Frequency |
| RFA | Request For Action |
| RH | Relative Humidity |
| SAM | Systems Assurance Manager |
| SCC | Stress Corrosion Cracking |
| SCD | Source Control Drawing |
| SCM | Software Configuration Management |
| SCR | System Concept Review |
| SEE | Single Event Effects |
| SEL | Single Event Latch-up |
| SEU | Single Event Upset |
| SOCC | Simulations Operations Control Center |
| SOW | Statement of Work |
| SQMS | Software Quality Management System |
| SRO | Systems Review Office |
| SRR | Software Requirements Review |
| SSHA | Subsystem Hazard Analysis |
| SSPP | System Safety Program Plan |
| SWAR | Software Acceptance Review |
| SWCCB | Software Configuration Control Board |
| SWCDR | Software Critical Design Review |
| SWPDR | Software Preliminary Design Review |
| SWRR | Software Requirements Review |
| SWTRR | Software Test Readiness Review |
| TID | Total Ionizing Dose |
| TML | Total Mass Loss |
| TRR | Test Readiness Review |
| URL | Uniform Resource Locator |
| V&V | Verification and Validation |
| VTL | Verification Tracking Log |

## 18.0 DEFINITIONS

The following definitions apply within the context of this document:

**Acceptance Tests:** The validation process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

**Audit:** A review of the Contractor's, contractor's or subcontractor's documentation or hardware to verify that it complies with project requirements.

**Collected Volatile Condensable Material (CVCM):** The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time.

**Configuration:** The functional and physical characteristics of the payload and all its integral parts, assemblies and systems that are capable of fulfilling the fit, form and functional requirements defined by performance specifications and engineering drawings.

**Configuration Control:** The systematic evaluation, coordination, and formal approval/disapproval of proposed changes and implementation of all approved changes to the design and production of an item the configuration of which has been formally approved by the contractor or by the purchaser, or both.

**Configuration Management:** The systematic control and evaluation of all changes to baseline documentation and subsequent changes to that documentation which define the original scope of effort to be accomplished (contract and reference documentation) and the systematic control, identification, status accounting and verification of all configuration items.

**Contamination:** The presence of materials of molecular or particulate nature which degrade the performance of hardware.

**Derating:** The reduction of the applied load (or rating) of a device to improve reliability or to permit operation at high ambient temperatures.

**Design Specification:** Generic designation for a specification that describes functional and physical requirements for an article, usually at the component level or higher levels of assembly. In its initial form, the design specification is a statement of functional requirements with only general coverage of physical and test requirements. The design specification evolves through the project life cycle to reflect progressive refinements in performance, design, configuration, and test requirements. In many projects the end-item specifications serve all the purposes of design specifications for the contract end-items. Design specifications provide the basis for technical and engineering management control.

**Designated Representative:** An individual (such as a NASA plant representative), firm (such as assessment contractor), Department of Defense (DOD) plant representative, or other government representative designated and authorized by NASA to perform a specific function for NASA. As related to the contractor's effort, this may include evaluation, assessment, design review, participation, and review/approval of certain documents or actions.

**Destructive Physical Analysis (DPA):** An internal destructive examination of a finished part or device to assess design, workmanship, assembly, and any other processing associated with fabrication of the part.

**Discrepancy:** See Nonconformance.

**Design Qualification Tests:** Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either “prototype” or “protoflight” test levels.

**Discrepancy:** See Nonconformance

**Electromagnetic Compatibility (EMC):** The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

**Electromagnetic Interference (EMI):** Electromagnetic energy that interrupts, obstructs, or otherwise degrades or limits the effective performance of electrical equipment.

**Electromagnetic Susceptibility:** Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

**End-to-End Tests:** Tests performed on the integrated ground and flight system, including all elements of the payload, its control, stimulation, communications, and data processing to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

**Failure:** A departure from specification that is discovered in the functioning or operation of the hardware or software. See nonconformance.

**Failure Modes and Effects Analysis (FMEA):** A procedure by which each credible failure mode of each item from a low indenture level to the highest is analyzed to determine the effects on the system and to classify each potential failure mode in accordance with the severity of its effect.

**Flight Acceptance:** See Acceptance Tests.

**Fracture Control Program:** A systematic project activity to ensure that a payload intended for flight has sufficient structural integrity as to present no critical or catastrophic hazard. Also to ensure quality of performance in the structural area for any payload (spacecraft) project. Central to the program is fracture control analysis, which includes the concepts of fail-safe and safe-life, defined as follows:

a. **Fail-safe:** Ensures that a structural element, because of structural redundancy, will not cause collapse of the remaining structure or have any detrimental effects on mission performance.

b. **Safe-life:** Ensures that the largest flaw that could remain undetected after non-destructive examination would not grow to failure during the mission.

**Functional Tests**: The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

**Hardware:** As used in this document, there are two major categories of hardware as follows:

a. **Prototype Hardware:** Hardware of a new design; it is subject to a design qualification test program; it is not intended for flight.

b. **Flight Hardware:** Hardware to be used operationally in space. It includes the following subsets:

**(1) Protoflight Hardware:** Flight hardware of a new design; it is subject to a qualification test program that combines elements of prototype and flight acceptance validation; that is, the application of design qualification test levels and duration of flight acceptance tests.

**(2) Follow-On Hardware:** Flight hardware built in accordance with a design that has been qualified either as prototype or as protoflight hardware; follow-on hardware is subject to a flight acceptance test program.

**(3) Spare Hardware:** Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.

**(4) Re-flight Hardware:** Flight hardware that has been used operationally in space and is to be reused in the same way; the validation program to which it is subject depends on its past performance, current status, and the upcoming mission.

**Inspection:** The process of measuring, examining, gauging, or otherwise comparing an article or service with specified requirements.

**Limit Level:** The maximum expected flight.

**Limited Life Items:** Spaceflight hardware (1) that has an expected failure-free life that is less than the projected mission life, when considering cumulative ground operation, storage and on-orbit operation, (2) limited shelf life material used to fabricate flight hardware.

**Margin:** The amount by which hardware capability exceeds mission requirements

**Material Review Board (MRB):** The formal Contractor board established for the purpose of reviewing, evaluating, and disposing of specific nonconforming materials, supplies or services, and for ensuring the implementation and accomplishment of corrective action to preclude recurrence.

**Monitor:** To keep track of the progress of a performance assurance activity; the monitor need not be present at the scene during the entire course of the activity, but he will review resulting data or other associated documentation (see Witness).

**Nonconformance:** A condition of any hardware, software, material, or service in which one or more characteristics do not conform to requirements. As applied in quality assurance, nonconformances fall into two categories--discrepancies and failures. A discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

**Nonconformance, critical.** A nonconformance that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the supplies or services; or is likely to prevent performance of a vital agency mission.

**Nonconformance, major.** A nonconformance, other than critical, that is likely to result in failure, or to materially reduce the usability of the supplies or services for their intended purpose.

**Nonconformance, minor.** A nonconformance that is not likely to materially reduce the usability of the supplies or services for their intended purpose, or is a departure from established standards having little bearing on the effective use or operation of the supplies or services.

**Offgassing:** The emanation of volatile matter of any kind from materials into a manned pressurized volume.

**Outgassing:** The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

**Performance Validation:** Determination by test, analysis, or a combination of the two that the payload element can operate as intended in a particular mission; this includes being satisfied that the design of the payload or element has been qualified and that the particular item has been accepted as true to the design and ready for flight operations.

**Protoflight Testing:** See Hardware.

**Prototype Testing:** See Hardware.

**Qualification:** See Design Qualification Tests.

**Redundancy (of design):** The use of more than one independent means of accomplishing a given function.

**Repair:** A corrective maintenance action performed as a result of a failure so as to restore an item to operate within specified limits.

**Rework:** Return for completion of operations (complete to drawing). The article shall be reprocessed to conform to the original specifications or drawings.

**Similarity, Validation by:** A procedure of comparing an item to a similar one that has been verified. Configuration, test data, application, and environment shall be evaluated. It should be determined that design-differences are insignificant, environmental stress will not be greater in the new application, and that manufacturer and manufacturing methods are the same.

**Single Point Failure:** A single element of hardware the failure of which would result in loss of mission objectives, hardware, or crew, as defined for the specific application or project for which a single point failure analysis is performed.

**Temperature Cycle:** A transition from some initial temperature condition to temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

**Temperature Stabilization:** The condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified test tolerance for the necessary duration or where further change is considered acceptable.

**Thermal Balance Test:** A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

**Thermal-Vacuum Test:** A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test, including the gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

**Torque Margin:** Torque margin is equal to the torque ratio minus one.

**Torque Ratio:** Torque ratio is a measure of the degree to which the torque available to accomplish a mechanical function exceeds the torque required.

**Total Mass Loss (TML):** Total mass of material outgassed from a specimen that is maintained at a specified constant temperature and operating pressure for a specified time.

**Validation:** See Performance Validation.

**Vibroacoustics:** An environment induced by high-intensity acoustic noise associated with various segments of the flight profile; it manifests itself throughout the payload in the form of directly transmitted acoustic excitation and as structure-borne random vibration.

**Waiver:** A written authorization to accept an item that is found to depart from specific requirements, either during the manufacturing process or after having been submitted for Government inspection or acceptance but nevertheless is considered “acceptable as is”, or after repair by an approved method.

**Waiver, Critical Waiver:** consists of acceptance of an item having a nonconformance with contract or configuration documentation involving safety.

**Waiver, Major Waiver:** consists of acceptance of an item having a nonconformance with contract or configuration documentation involving a) performance, b) interchangeability, reliability, survivability or maintainability, c) effective use or operation, d) weight or e) appearance.

**Waiver, Minor Waiver:** consists of acceptance of an item having a nonconformance with contract or configuration documentation which does not involve any of the factors listed in the above definition for a major waiver.

**Workmanship Tests:** Tests performed during the environmental validation program to verify adequate workmanship in the construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Thus random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted parts, etc. Cycling between temperature extremes during thermal-vacuum testing and the presence of electromagnetic interference during EMC testing can also reveal the lack of proper construction and adequate workmanship.

**Witness:** A personal, on-the-scene observation of a performance assurance activity with the purpose of verifying compliance with project requirements (see Monitor).

# 19.0 DATA ITEM DESCRIPTIONS

## 19.1 DID 1-1: Mission Assurance Plan

| Title: Mission Assurance Plan | CDRL No.: 1-1 |
|---|---|
| Reference: Paragraph 1.1 | |
| Use: Documents the Contractor's Mission Assurance Implementation approach. | |
| Related Documents: ANSI/ISO/ASQC Q9001: 1994, ANSI/ISO/ASQ Q9001:2000, SAE AS9100 and ISO 10013, SMR-5000 | |
| Place/Time/Purpose of Delivery: Provide during development phase for GSFC review. | |

Preparation Information:

The plan shall address the Contractor's implementation of the HRSDM Mission Assurance Requirements. The following topics shall be addressed:

1. Configuration Management
2. System Safety
3. Reliability Assurance
4. Risk Management
5. Design Verification
6. Workmanship Standards
7. Electronic Parts Control
8. Materials Control
9. Contamination Control
10. ESD Protection
11. GIDEP Alerts

## 19.2 DID 1-2: End Item Data Package

| Title: End Item Data Package | CDRL No.: 1-2 |
|---|---|
| Reference: Paragraph 1.4 | |
| Use: Provides documented verification of the space-flight quality of delivered hardware. | |
| Related Documents: SMR-5000 | |
| Place/Time/Purpose of Delivery: Provide for GSFC review at the Pre-Ship Review (PSR) and deliver to GSFC with the hardware. | |

Preparation Information:

An End Item Data Package shall be provided for each delivered item or system. The format of the package shall be determined by the Contractor. The package shall include, but not limited to the following information:

1. As-Built hardware documentation describing accurately the configuration of each serialized assembly:
    a. Part number and revision of each item.
    b. Part description of each item.
    c. Procurement specification or SCD number
    d. Electronic part reference designation.
    e. Manufacturer.
    f. Parts, Materials, and Lubricant lists.
    g. Actual part markings
    h. Lot/Date Code (as applicable).
    i. Test lot number (as applicable)
    j. Wafer and lot number (as applicable)
    k. Serial number

2. Complete quality history of the items, including all manufacturing travelers.
3. Shortages list.
4. Operating times.
5. List of tests performed and results for each test.
6. Copies of all anomaly reports, both open and closed.
7. Deviations and Waivers.
8. MUAs
9. MRBs.
10. Evidence of Contractor QA acceptance.
11. Environmental test reports.
12. Closeout photographs.
13. Drawings, ICDs, etc.

In addition, the Contractor shall also determine and provide appropriate End Item Data Packages for delivered GSE systems.

## 19.3 DID 2-1: Quality Manual

| Title: Quality Manual | CDRL No.: 2-1 |
|---|---|
| Reference: Paragraph 2.0 | |
| Use: Documents the Contractor's quality management system. | |
| Related Documents: ANSI/ISO/ASQC Q9001: 1994, ANSI/ISO/ASQ Q9001:2000, SAE AS9100 and ISO 10013. | |
| Place/Time/Purpose of Delivery: Provide with proposal for GSFC review. Provide Quality Manual updates to GSFC Project Office for review prior to implementation, or Provide with proposal for information along with evidence of third party certification/registration of the Contractor's quality management system by an accredited registrar. | |
| Preparation Information: Prepare a Quality Manual addressing all applicable requirements of relevant quality standard (Q9001, AS9100, etc). Refer to ISO 10013 for further guidelines on preparation of a quality manual. The Quality Manual shall contain: a. the title, approval page, scope and the field of application; b. table of contents; c. introductory pages about the organization concerned and the manual itself; d. the quality policy and objectives of the organization; e. the description of the organization, responsibilities and authorities, including the organization responsible for the EEE parts, materials, reliability, safety and test requirements implementation; f. a description of the elements of the quality system, Contractor policy regarding each element and Contractor implementation procedure for each clause or reference(s) to approved quality system procedures; system level procedures shall address the | |

implementation of all requirements cited in this document.

g. a definitions section, if appropriate;

h. an appendix for supportive data, if appropriate.

Quality Manual distribution and changes shall be implemented by a controlled process. The Quality Manual shall be maintained/updated by the Contractor throughout the life of the contract.

## 19.4 DID 3-1: System Safety Program Plan

| Title: System Safety Program Plan | CDRL No.: 3-1 |
|---|---|
| Reference: Paragraph 3.2.1 | |
| Use: The approved plan provides a formal basis of understanding between GSFC and the Contractor on how the System Safety Program will be conducted to meet the applicable launch range safety requirements. The approved plan shall account for all contractually required tasks and responsibilities on an item-by-item basis. | |
| Related Documents:<br>a. EWR 127-1, Eastern Western Range System Safety Requirements<br>b. NPG 7120.5, Program and Project Management Processes and Requirements<br>c. NPD 8700.1, NASA Policy for Safety and Mission Success<br>d. NSTS 1700.7B | |
| Place/Time/Purpose of Delivery: The Range User shall submit a draft SSPP to GSFC for review and approval within 45 days of contract award and a final at least 45 days prior to any program CDR. | |
| Product Preparation: The SSPP shall describe in detail tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate and control hazards, or reduce the associated risk to an acceptable level throughout the system life cycle. | |
| | |

## 19.5 DID 3-2 Safety Assessment Report (SAR)

| Title: | CDRL No.: |
|---|---|
| Safety Assessment Report (SAR) | 3-2 |
| Reference: | |
| Paragraph 3.3 | |
| Use: | |
| The Safety Assessment Report (SAR) is used to document a comprehensive evaluation of the mishap risk being assumed prior to the testing or operation of an instrument. The SAR will be provided to the spacecraft contractor as an input to their preparation of the Missile System Prelaunch Safety Package (MSPSP), which is one of the media through which missile system prelaunch safety approval is obtained. | |
| Related Documents: | |
| EWR 127-1, Eastern Western Range System Safety Requirements | |
| Place/Time/Purpose of Delivery: | |
| SAR delivery shall support the spacecraft contractor's MSPSP submittal schedule. The final MSPSP will be submitted to Range Safety at least 45 calendar days prior to hardware shipment to Range. Preliminary shipment will be TBD based on negotiation between the spacecraft contractor and the Range. GSFC will approve all deliveries/versions. | |

Preparation Information:

The Safety Assessment Report will identify all safety features of the hardware, software, and system design as well as procedural, hardware, and software related hazards that may be present in the system being acquired. This includes specific procedural controls and precautions that should be followed. The safety assessment will summarize the following information:

1. The safety criteria and methodology used to classify and rank hazards plus any assumptions upon which the criteria or methodologies were based or derived including the definition of acceptable risk as specified by Range Safety
2. The results of analyses and tests performed to identify hazards inherent in the system including:
   a. Those hazards that still have a residual risk and the actions that have been taken to reduce the associated risk to a level contractually specified as acceptable
   b. Results of tests conducted to validate safety criteria, requirements, and analyses
3. The results of the safety program efforts including a list of all significant hazards along with specific safety recommendations or precautions required to ensure safety of personnel, property, or the environment. **NOTE:** The list shall be categorized as to whether or not the risks may be expected under normal or abnormal operating conditions.
4. Any hazardous materials generated by or used in the system
5. The conclusion, including a signed statement, that all identified hazards have been eliminated or their associated risks controlled to levels contractually specified as acceptable and that the system is ready to test or operate or proceed to the next acquisition phase
6. Recommendations applicable to hazards at the interface of Range User systems with other systems, as required

## 19.6 DID 3-3: Safety Data Package

| Title: | CDRL No.: |
|---|---|
| Safety Data Package (SDP) | 3-3 |

Reference:

Paragraph 3.4

Use:

Provide a detailed description of the payload design sufficient to support hazard analysis results, hazard analysis method, and other applicable safety related information. The Contractor shall include analyses identifying the ground operations hazards associated with the flight system, ground support equipment, and their interfaces. The Contractor shall take measures to minimize each significant identified hazard.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements

b. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook

Note: Other launch range and launch vehicle requirements may apply

Place/Time/Purpose of Delivery:

In general provide preliminary (combined flight and ground safety package) with Preliminary Design Review (PDR) package, update at Critical Design Review (CDR), final 60 days before Pre Ship Review (PSR). *

*(See applicable launch range and launch vehicle requirements for details).

SAFETY DATA PACKAGE (cont)

Preparation Information:

The Safety Package shall include the following information:

1. Introduction. State, in narrative form, the purpose of the safety data package.

2. System Description. This section may be developed by referencing other program documentation such as technical manuals, System Program Plan, System Specification, etc.

   As applicable, either photos, charts, flow/functional diagrams, sketches, or schematics to support the system description, test, or operation.

3. System Operations.

a. A description or reference of the procedures for operating, testing and maintaining the system. Discuss the safety design features and controls incorporated into the system as they relate to the operating procedures.

b. A description of any special safety procedures needed to assure safe operations, test and maintenance, including emergency procedures.

c. A description of anticipated operating environments and any specific skills required for safe operation, test, maintenance, transportation or disposal.

d. A description of any special facility requirements or personal equipment to support the system.

SAFETY DATA PACKAGE (cont)

4. Systems Safety Engineering Assessment. This section shall include:

a. A summary or reference of the safety criteria and methodology used to classify and rank hazardous conditions.

b. A description of or reference to the analyses and tests performed to identify hazardous conditions inherent in the system.

(1) A list of all hazards by subsystem or major component level that have been identified and considered from the inception of the program.

a. A discussion of the hazards and the actions that have been taken to eliminate or control these items.

b. A discussion of the effects of these controls on the probability of occurrence and severity level of the potential mishaps.

c. A discussion of the residual risks that remain after the controls are applied or for which no controls could be applied.

d. A discussion of or reference to the results of tests conducted to validate safety criteria requirements and analyses. These items shall be tracked and closed-out via a Verification Tracking Log (VTL).

SAFETY DATA PACKAGE (cont)

Preparation Information (continued):

5. Conclusions and Recommendations. This section shall include:
   a. A short assessment of the results of the safety program efforts. A list of all significant hazards along with specific safety recommendations or precautions required ensuring the safety of personnel and property.
   b. For all hazardous materials generated by or used in the system, the following information shall be included.
      (1) Materiel identification as to type, quantity, and potential hazards.
      (2) Safety precautions and procedures necessary during use, storage, transportation, and disposal.
      (3) A copy of the Material Safety Data Sheet (OSHA Form 20 or DD Form 1813) as required.
   c. Reference material to include a list of all pertinent references such as Test Reports, Preliminary Operating Manuals and Maintenance Manuals
   d. A statement signed by the Contractor System Safety Manager and the Program Manager certifying that all identified hazards have been eliminated or controlled and that the system is ready to test, operate, or proceed to the next acquisition phase. In addition, include recommendations applicable to the safe interface of this system with the other system(s).

6. The safety package shall be submitted for approval in accordance with the milestones required by the applicable launch site and launch vehicle safety regulation.

## 19.7 DID 3-4: Hazard Control Verification and Tracking

| Title: | CDRL No.: |
|---|---|
| Hazard Control Verification and Tracking | 3-4 |

Reference:

Paragraph 3.4

Use:

To provide a Hazard Control and Verification Tracking process or "closed-loop system" to assure safety compliance has been satisfied in accordance to applicable launch range safety requirements.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements

b. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook

Place/Time/Purpose of Delivery:

Provide hazard control verification and tracking system in accordance with applicable launch site range safety requirements. Documented methods of hazard controls shall be submitted with the initial SDP, MSPSP, or SAR and updated with each consecutive submittal. All open hazard control verification items must be closed in accordance with applicable launch site range safety requirements.

Preparation Information:

Provide documentation that demonstrates the process of verifying the control of all hazards by test, analysis, inspection, similarity to previously qualified hardware, or any combination of these activities. All verifications that are listed on the hazard reports shall reference the tests/analyses/inspections. Results of these tests/analyses/inspections shall be available for review and submitted in accordance with the contract schedule and applicable launch site range safety requirements.

## 19.8 DID 3-5: Ground Operations Procedures

| Title: | CDRL No.: |
|---|---|
| Ground Operations Procedures | 3-5 |

Reference:

Paragraph 3.5

Use:

All ground operations procedures to be used at GSFC facilities, other integration facilities, or the launch site shall be submitted to GSFC for review and concurrence. Launch site ground operations procedures shall be submitted to applicable Range Safety 45 days prior to use.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements

b. KHB 1710.2, Kennedy Space Center Safety Practices Handbook

Note: Other launch vehicle and/or contractor, or commercial facility requirements may apply

Place/Time/Purpose of Delivery:

Provide preliminary 120 days prior to PSR, final 60 days before PSR, and submit to applicable Range Safety 45 days prior to use.

Preparation Information:

All hazardous operations as well as the procedures to control them shall be identified and highlighted. All launch site procedures shall comply with the applicable launch site safety regulation.

## 19.9 **DID 3-6: Safety Nonconformance Requests**

| Title: | CDRL No.: |
|---|---|
| Safety Noncompliance Requests | 3-6 |

Reference:

Paragraph 3.6

Use:

The hardware Contractor shall submit to the HST Project Safety Manager (PSM) an associated safety noncompliance request that identifies the hazard and shows the rationale for approval of a noncompliance when a specific safety requirement cannot be met, as defined in the applicable launch site safety regulation. The request may require Range Safety concurrence for the noncompliance request to be approved.

Related Documents:

a. EWR-127, Eastern Western Range System Safety Requirements

b. KHB 1710.2, Kennedy Space Center Safety Practices Handbook

Place/Time/Purpose of Delivery:

As identified to the HST Project Safety Manager

Preparation Information:

The noncompliance request shall include the following information resulting from a review of each waiver or deviation request.

a. A statement of the specific safety requirement and its associated source document name and paragraph number, as applicable, for which a waiver or deviation is being requested.

b. A detailed technical justification for the exception.

c. Analyses to show that the mishap potential of the proposed alternate requirement, method or process, as compared to the specified requirement.

d. A narrative assessment of the risk involved in accepting the waiver or deviation. When it is determined that there are no hazards, the basis for such determination should be provided.

e. A narrative on possible ways of reducing hazards severity and probability and existing compliance activities (if any).

f. Starting and expiration date for waiver/deviation.

## 19.10 DID 3-7: Orbital Debris Assessment

| Title: Orbital Debris Assessment | CDRL No.: 3-7 |
|---|---|
| Reference: Paragraph 3.8 | |
| Use: Ensure NASA requirements for post mission orbital debris control are met. | |
| Related Documents:<br>a. NPD 8710.3, NASA Policy for Limiting Orbital Debris Generation<br>b. NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris | |
| Place/Time/Purpose of Delivery: Provide preliminary assessment prior PDR, updated package 45 days prior to CDR and a final package at PER | |
| Preparation Information:<br>The assessment shall be done in accordance with NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris. The preliminary debris assessment should be conducted to identify areas where the program or project might contribute debris and to assess this contribution relative to the guidelines in so far as is feasible. Prior to CDR another debris assessment should be completed. This report should comment on changes made since the PDR report. The level of detail should be consistent with the available information of design and operations. When there are design changes after CDR that impact the potential for orbital debris generation, and update of the debris assessment report should be prepared, approved, and coordinated with the Office of System Safety and Mission Assurance.<br><br>Orbital Debris Assessment Software is available for download from Johnson Space Center at URL:<br>http://sn-callisto.jsc.nasa.gov/mitigate/das/das.html | |

## 19.11 DID 12-1: Polymeric Materials and Composites Usage List

| Title: Polymeric Materials and Composites Usage List | CDRL No.: 12-1 |
|---|---|
| Reference: Paragraph 12.2.2 | |
| Use: For usage evaluation and approval of all polymeric and composite materials applications. | |
| Related Documents: NASA RP-1124, ASTM E 595, MSFC-HDBK-527, NHB 1700.7, EWR 127.1 GMI 1700.3, NASA-STD-6001 | |
| Place/Time/Purpose of Delivery: Provide to the HST MAE 30 days before Contractor PDR for review, 30 days before Contractor CDR for approval and 30 days before acceptance for approval. | |

Preparation Information:

The Contractor shall provide the information requested on the polymeric materials and composites usage list form, the equivalent information on the Contractor's form or the equivalent information electronically. The form is in the Mission Assurance Guide.

The polymeric materials and composites usage list (1) form requires, as a minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, Contractor, address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, date evaluated, item number, material identification (2), mix formula (3), cure (4), amount code, expected environment (5), outgassing values and reason for selection (6). Notes 1 through 6 are listed below:

1. List all polymeric materials and composites applications utilized in the system except lubricants that should be listed on polymeric and composite materials usage list.
2. Give the name of the material, identifying number and manufacturer Example: Epoxy, Epon 828, E. V. Roberts and Associates
3. Provide proportions and name of resin, hardener (catalyst), filler, etc. Example: 828/V140/Silflake 135 as 5/5/38 by weight
4. Provide cure cycle details. Example: 8 hrs. at room temperature + 2 hrs. at 150C
5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group. Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV)

   Storage: up to 1 year at room temperature

   Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen
6. Provide any special reason why the materials were selected. If for a particular property, please give the property. Example: Cost, availability, room temperature curing or low thermal expansion.

### 19.12 DID 12-2: Inorganic Materials and Composites Usage List

| Title: Inorganic Materials and Composites Usage List | CDRL No.: 12-2 |
|---|---|
| Reference: Paragraph 12.2.6 | |
| Use: For usage evaluation and approval of all metal, ceramic and metal/ceramic composite material applications. | |
| Related Documents: MSFC-HDBK-527, NHB 1700.7, MSFC-SPEC-522 | |

Place/Time/Purpose of Delivery:

Provide to the GSFC Project Office 30 days before Contractor PDR for review, 30 days before Contractor CDR for approval and 30 days before acceptance for approval.

Preparation Information:

The hardware provider shall provide the information requested on the inorganic materials and composites usage list, the equivalent information on the hardware Contractor's forms or the equivalent information electronically.

The inorganic materials and composite usage list (1) form requires, as a minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, Contractor, Contractor address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, item number, materials identification (2), condition (3), application or usage (4), expected environment (5), stress corrosion cracking table number, MUA number and NDE method. Notes 1 through 5 are listed below:

List all inorganic materials (metals, ceramics, glasses, liquids and metal/ceramic composites) except bearing and lubrication materials that should be listed on Form 18-59C.

Give materials name, identifying number manufacturer. Example:

a. Aluminum 6061-T6
b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc
c. Fused silica, Corning 7940, Corning Class Works

Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc. Example:

a. Heat-treated to Rockwell C 60 hardness, gold electroplated, brazed.
b. Surface coated with vapor deposited aluminum and magnesium fluoride
c. Cold worked to full hare condition, TIG welded and electroless nickel-plated.

Give details of where on the spacecraft the material shall be used (component) and its function. Example: Electronics box structure in attitude control system, not hermetically sealed.

Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group. Example:

a. T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
b. Storage: up to 1 year at room temperature
c. Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxygen